

RANDOMIZED PROSPECTIVE STUDY OF
COMPARING SUPRACLAVICULAR BLOCK OF
BRACHIAL PLEXUS USING ULTRASONIC GUIDANCE
AND NEUROSTIMULATION WITH A TECHNIQUE
USING ANATOMICAL LANDMARKS AND
NEUROSTIMULATION

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CERTIFICATE

This is to certify that the dissertation entitled, “**RANDOMIZED PROSPECTIVE STUDY OF COMPARING SUPRACLAVICULAR BLOCK OF BRACHIAL PLEXUS USING ULTRASONIC GUIDANCE AND NEUROSTIMULATION WITH A TECHNIQUE USING ANATOMICAL LANDMARKS AND NEUROSTIMULATION**”

submitted by **Dr.SHARADHA DEVI.G.** in partial fulfillment for the award of the degree of Doctor of Medicine in Anesthesiology by the Tamilnadu Dr.M.G.R. Medical University, Chennai is a bonafide record of the work done by her in the Department of Anesthesiology, Madras Medical College, during the academic year 2007 -2010.

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INTRODUCTION

Peripheral nerve blocks provide ideal operating conditions when used optimally. They are said to cause least interference with the vital physiological functions of the body and reduced stress response avoiding polypharmacy with an alert, awake and co-operative patient when compared to other conventional techniques. Adequately administered regional anaesthesia can not only provide excellent intraoperative pain relief but also good post operative analgesia.

Regional anaesthesia traces its origin to Dr. Carl Koller, a young Viennese Ophthalmologist, who in 1884 employed a solution of cocaine for topical corneal anaesthesia in patients undergoing eye surgeries. Most of the local anaesthetic agents developed in the first half of 20th century (1900 – 1940) were basically amino ester compounds. They lost their importance due to their shorter duration of action and associated allergic reactions and systemic toxicity. This paved the way for the synthesis of newer agents namely the aminoamide compounds.

Brachial Plexus block¹ was first performed by William Stewart Halsted in 1889. He directly exposed the brachial plexus in the neck to

perform the block and used cocaine. Hirschel first described the percutaneous approach to the brachial plexus. Kulenkampff first described the classical supraclavicular approach to the brachial plexus. The subclavian perivascular block was first described by Winnie and Collins. The infraclavicular approach was first developed by Raj. The axillary approach was first performed by Accardo and Adriano in 1949.

Regional blocks have traditionally been performed using nerve stimulation, anatomical landmarks and or fascia clicks. Blind blocks that rely solely on anatomical landmarks are known to produce serious complications. Even the technique of nerve stimulation which has been recommended as the gold standard for nerve identification in regional blocks over the past decade fails to ensure an adequate level of nerve block. It also carries a risk of damage to nerve structures by direct puncture.

Ultrasound visualisation of anatomical structures offers safe blocks of superior quality by optimal needle positioning. The use of ultrasound for nerve blocks was first reported by La Grange and colleagues in 1978 who performed supraclavicular brachial plexus blocks with the help of a Doppler ultrasound blood flow detector. In 1994, Stephan Kapral et al published the

first reported use of direct sonographic visualisation for regional anaesthesia.

Over the past ten years however dramatic progress has been made.

The present study was designed to compare supraclavicular blockade using ultrasonic guidance and neuro stimulation to supraclavicular blockade using a surface anatomy approach and neurostimulation.

AIM OF THE STUDY

The aim of the study is:

- a. To compare the efficacy,safety,and execution time of supraclavicular block of brachial plexus using ultrasonic guidance and neuro stimulation compared with a supraclavicular technique that used anatomical landmarks and neurostimulation.
- b. To study the associated complications of the procedure.

APPLIED PHYSIOLOGY

PHYSIOLOGY OF NERVE CONDUCTION: ²

Neurons are the basic building blocks of the nervous system that respond to various stimuli. Integration and transmission of nerve impulses are specialised functions of neurons.

All peripheral nerves are elongated axons of neurons situated centrally. A typical peripheral nerve consists of bundles of motor, sensory and other fibres enclosed in the outermost covering called epineurium. Inside the epineurium, the perineurium surrounds the collection of bundles. Each bundle is surrounded by an endoneurium. Each nerve fibre in a bundle is enclosed in a layer of neurilemma or the axonal membrane.

Depending on the presence or absence of myelin sheath, it can be a myelinated nerve fibre or unmyelinated nerve fibre.

The axonal membrane itself is made up of a bimolecular lipid palisade, interspersed with large protein molecules. The membrane lipids are largely phospholipids composed of a polar head group and a non polar hydrocarbon tail.

The primary function of the cell membrane is to separate the extracellular from the intracellular environment. The major difference between these two environments is the ionic concentration. This disequilibrium provides the means for impulse conduction.

The most important ions in this respect are Sodium and Potassium. A membrane bound protein sodium potassium ATPase maintains normal resting equilibrium potential between -50mv to -90mv by pumping sodium ions out of the cell and potassium ions into the cell. A positive ion gradient from inside the membrane to the outside causes electro negativity inside the membrane.

During nerve conduction the following changes occur in the cell membrane.

IN THE RESTING PHASE:

There is a potential difference across the membrane inside is negative, due to a higher concentration of Sodium ions outside than inside the cell.

K^+ moves out of cells and Na^+ moves in but because of more K^+ channels opened at rest, K^+ permeability is greater than Na^+ permeability. Therefore K^+ channels maintain the resting membrane potential.

DEPOLARIZATION PHASE:

During excitation, Na^+ channels in the cell membrane open briefly allowing sodium ions to flow into the cell, thereby depolarizing the membrane.

REPOLARIZATION PHASE:

During this phase, opening of voltage gated K^+ channel occurs, results in passing of Potassium ions out of the cell to restore electrical neutrality.

RESTORATION PHASE:

During this phase, sodium ions return to the outside and potassium ions re-enter the cell.

DISTRIBUTION OF ION CHANNELS IN MYELINATED NEURONS:

Voltage gated Na^+ channels are highly concentrated in the nodes of Ranvier and the initial segment in myelinated neurons.

The initial segment and in sensory neurons, the first node of Ranvier are the sites where impulses are normally generated and the other nodes of

Ranvier are the sites to which the impulses jump during saltatory conduction.

The sodium channel is believed to be an integral membrane spanning protein. The three dimensional configuration of the proteins forms a pore through the neuronal membrane.

Depolarization of the cell induces a configurational change on the sodium channel which causes it to open and allow ion passage.

In many myelinated neurons, the Na^+ channels are flanked by K^+ channels that are involved in repolarization.

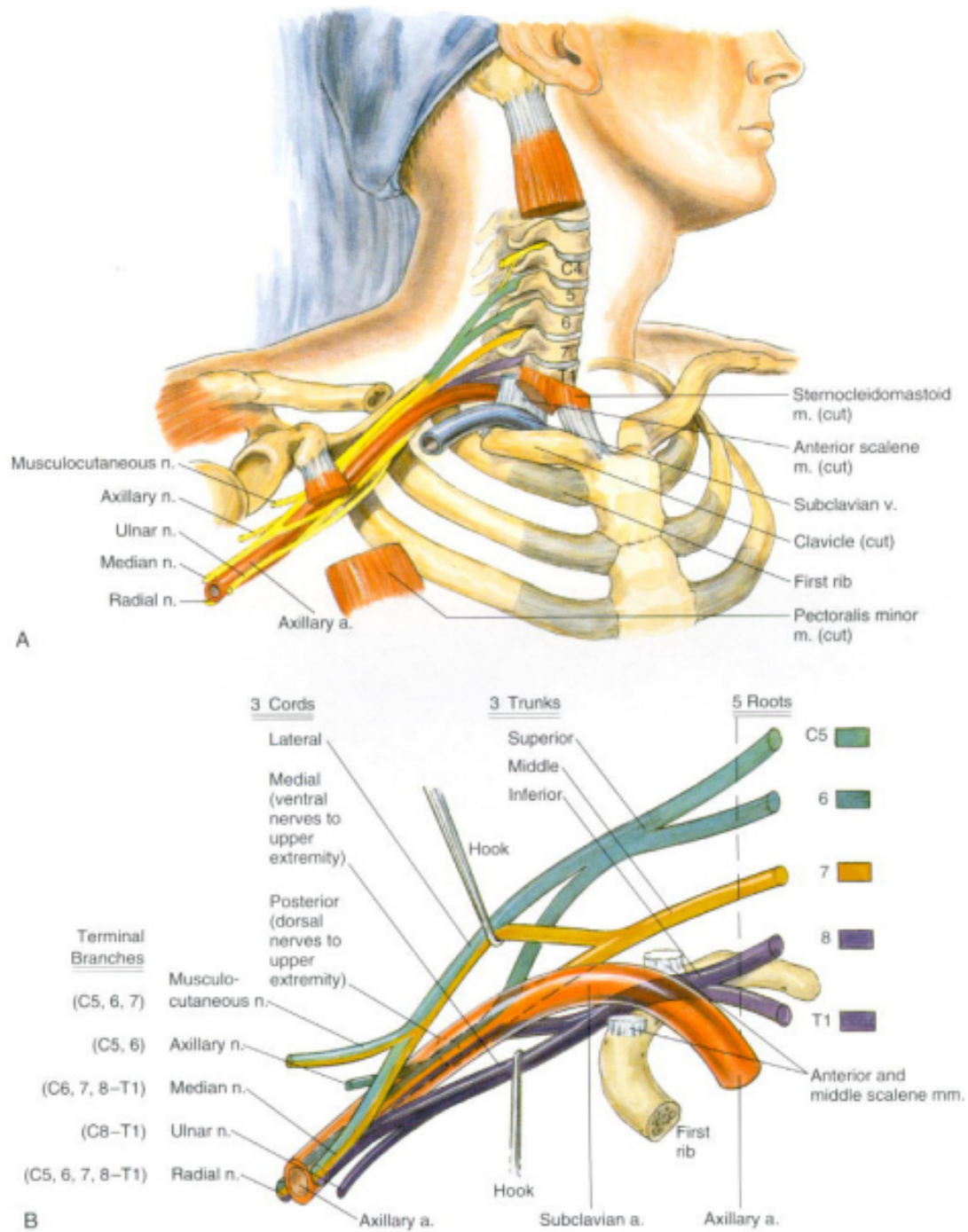
ACTION OF LOCAL ANAESTHETICS ON NERVE FIBRES: ³

The primary action of local anaesthetics on the nerves is electrical stabilization. The large transient increase in permeability to Na^+ ions necessary for propagation of the nerve impulse is prevented. Thus the resting membrane potential is maintained and depolarization in response to stimulation is inhibited.

Local anaesthetics block sodium conductance by:

1. Binding of local anaesthetics to sites on voltage gated Na^+ channels prevents opening of the channels by inhibiting the conformational changes that underlie channel activation.
2. Local anaesthetics produce nonspecific membrane expansion. There is an unfolding of membrane protein together with a disordering of the lipid component of the cell membrane with consequent obstruction of the sodium channel.

FIG – 1



ANATOMY OF THE BRACHIAL PLEXUS

THE BRACHIAL PLEXUS: ⁶ FIG - 1

Brachial Plexus is one of the most commonly used peripheral nerve blocks in clinical practice. So knowledge of the formation of the brachial plexus and of its distribution is absolutely essential for the effective use of brachial plexus block for surgeries of the upper limb. Absolute familiarity with the Vascular, Muscular and fascial relationship of the brachial plexus throughout its formation and distribution is equally essential for the mastery of various techniques of brachial plexus anaesthesia.

In its course from the intervertebral foramina to the upper arm, the fibres that constitute the plexus are composed consecutively of roots, trunks, cords, divisions and terminal nerves which are formed through a complex process of combining, dividing, recombining and finally redividing.

FORMATION OF THE PLEXUS:

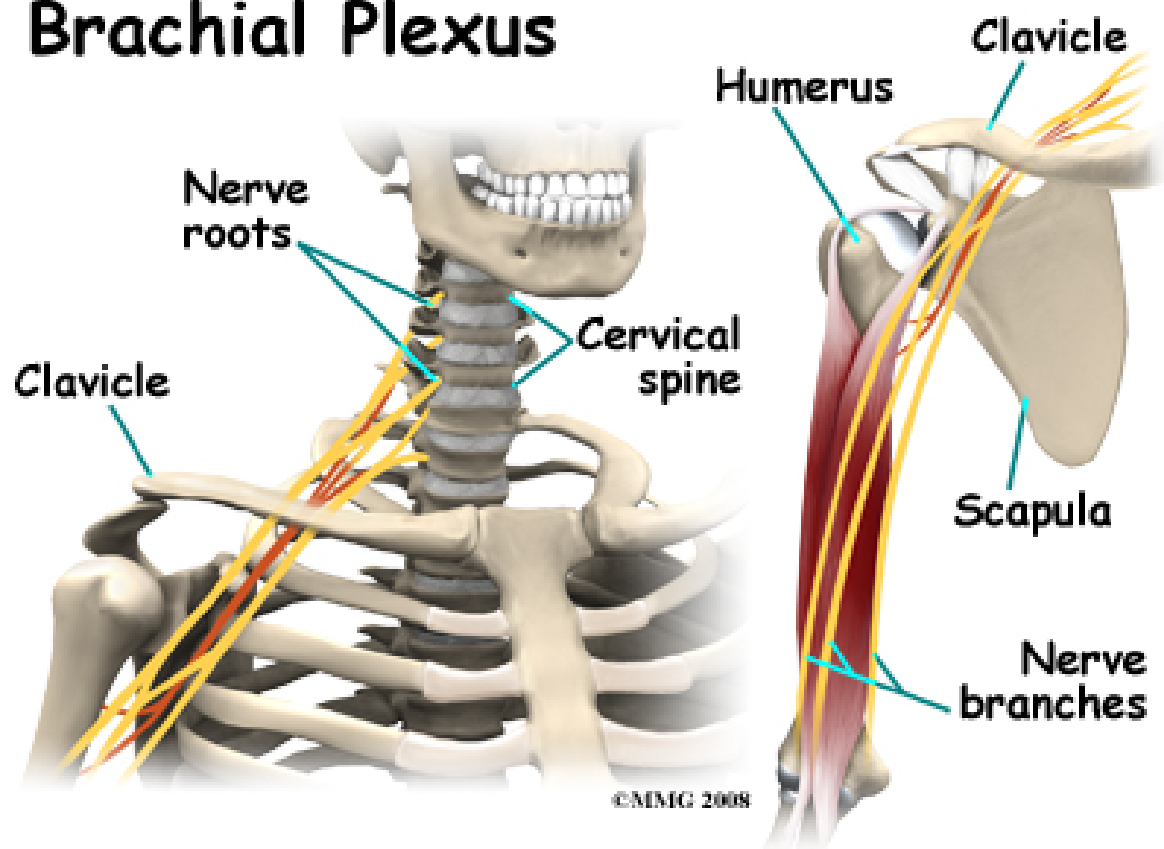
ROOTS:

The plexus is formed by the anterior primary rami of 5th to 8th cervical plexus together with the bulk of the 1st thoracic nerve (C_8 - T_1). In addition, there is frequently a combination from C_4 to the 5th cervical roots and

another below the T_2 to the 1st thoracic nerve. Occasionally the plexus is mainly derived from C_4 - C_8 (prefixed plexus) or from C_6 - T_2 (post fixed plexus).

FIG - 2

Brachial Plexus



TRUNKS:

The five roots of the brachial plexus emerge from the intervertebral foramina. They lie in the gutter between the anterior and posterior tubercles of the corresponding transverse process. All five roots then become sandwiched between Scalenus anterior and Scalenus medius. Here the roots of C₅ and C₆ unite into the upper trunk, the root of C₇ continues as the middle trunk and those of C₈ and T₁ into the lower trunk. Each trunk divides behind the clavicle, into anterior and posterior divisions which unite in the axilla to form cords.

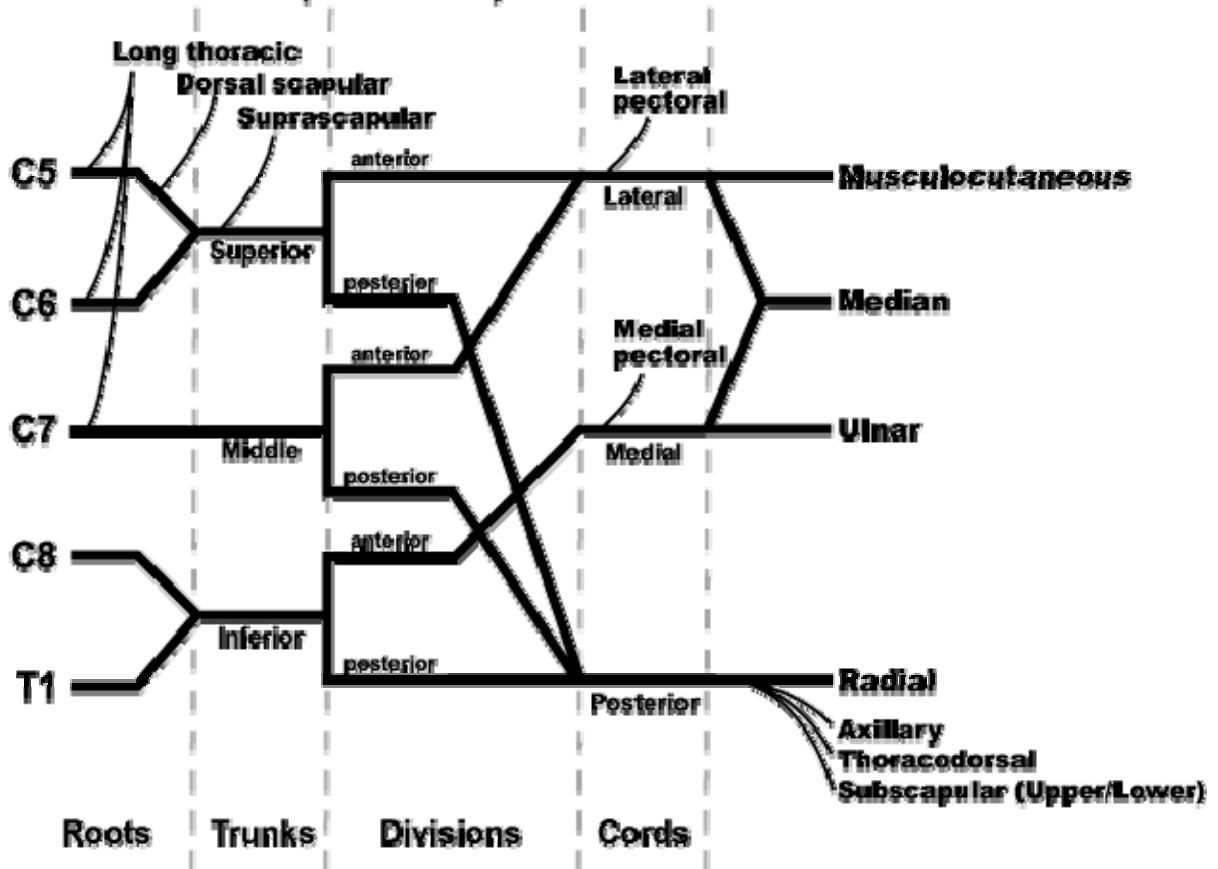
CORDS:

The six divisions stream into axilla and there join up into three cords; lateral, medial and posterior. These cords are composed as follows:

The union of the anterior divisions of the Upper and middle trunks form the lateral cord. The medial cord represents the continuation of the anterior division of the lower trunk. The posterior cord comprises of the posterior divisions of all the three trunks. The composition of brachial plexus can be summarised as follows:

FIG - 3

Brachial Plexus (schematic)



1. Five roots (between the scalene muscles) - the anterior primary rami of C_5 - C_8 and T_1 .
2. Three trunks (in the posterior triangle)
 - a) Upper trunk C_5 and C_6
 - b) Middle trunk C_7 alone
 - c) Lower trunk C_8 and T_1
3. Six divisions (behind the Clavicle)

Each trunk divides into an anterior and posterior division.
4. Three cords (within the axilla)
 - a) Lateral Cord - the fused anterior divisions of the upper and middle trunks C_5 - C_7
 - b) Medial Cord - the anterior division of the lower trunk C_8 - T_1
 - c) Posterior Cord formed by the union of the posterior divisions of all three trunks C_5 - T_1

RELATIONS OF THE BRACHIAL PLEXUS:

ROOTS:

Lie between the Scalenus anterior and Scalenus medius. The roots of the Plexus lie above the second part of the subclavian artery.

TRUNKS:

In the Posterior triangle, the trunks of the plexus invested in a sheath of prevertebral fascia, are superficially placed, being covered by skin, platysma and deep fascia.

The upper and middle trunks lie above the subclavian artery as they stream across the first rib, but the lower trunk lies behind the artery and may groove the rib immediately posterior to the subclavian groove.

DIVISIONS:

At the lateral border of the first rib, the trunks bifurcate into divisions which are situated behind the clavicle, subclavius muscle and the suprascapular vessels.

CORDS:

The cords are formed at the apex of the axilla and become grouped around the axillary artery.

THE INTERSCALENE SHEATH:

As the roots emerge in the groove between the transverse process of the tubercle, they lie in a fibrofatty space between two layers of fibrinous sheath. Posterior Sheath from the posterior tubercles covers the front of the medius, anterior sheath from anterior tubercles cover the posterior aspect of the Scalenus anterior. The sheath extends into the axilla around the plexus. Significance of this space is that the local anaesthetic can be injected to produce block at various sites by interscalene, subclavian perivascular or the axillary approach.

SYMPATHETIC SUPPLY:

Close to the emergence the 5th and 6th Cervical nerves receive a grey ramus from the middle cervical sympathetic ganglion. The 7th and 8th cervical nerves each receive a grey ramus from the inferior cervical ganglion and from T1 ganglion

BRANCHES:

Branches are given off from roots, trunks and cords.

1. Branches from the roots:

a) Nerve to the serratus anterior C_5 , C_6 and C_7

b) Muscular branches to

- Longus cervicis C_5 - C_8

- Three Scalene C_5 - C_8

- Rhomboids C_5

c) Twig to the Phrenic nerve C_5

2. Branches from the trunks:

a) Suprascapular nerve C_5 - C_6

b) Nerve to subclavius C_5 - C_6

3. Branches from the Cords:

a) Lateral Cord

- Lateral Pectoral nerve C_5-C_7
- Lateral head of median nerve C_5-C_7
- Musculocutaneous nerve C_5-C_7

b) Medial Cord

- Medial Pectoral nerve $C_8 - T_1$
- Medial head of median nerve $C_8 - T_1$
- Medial Cutaneous nerve of arm $C_8 - T_1$
- Medial Cutaneous nerve of forearm $C_8 - T_1$
- Ulnar nerve of arm $C_7, C_8 - T_1$

c) Posterior Cord

- Upper Subscapular nerve C_5-C_6
- Lower Subscapular nerve C_5-C_6

- Nerve to latissimus dorsi C₆, C₇, C₈
- Axillary nerve C₅-C₆
- Radial nerve C₅, C₆, C₇, C₈, T₁

ANATOMIC CONSIDERATIONS OF THE INTERSCALENE SPACE:

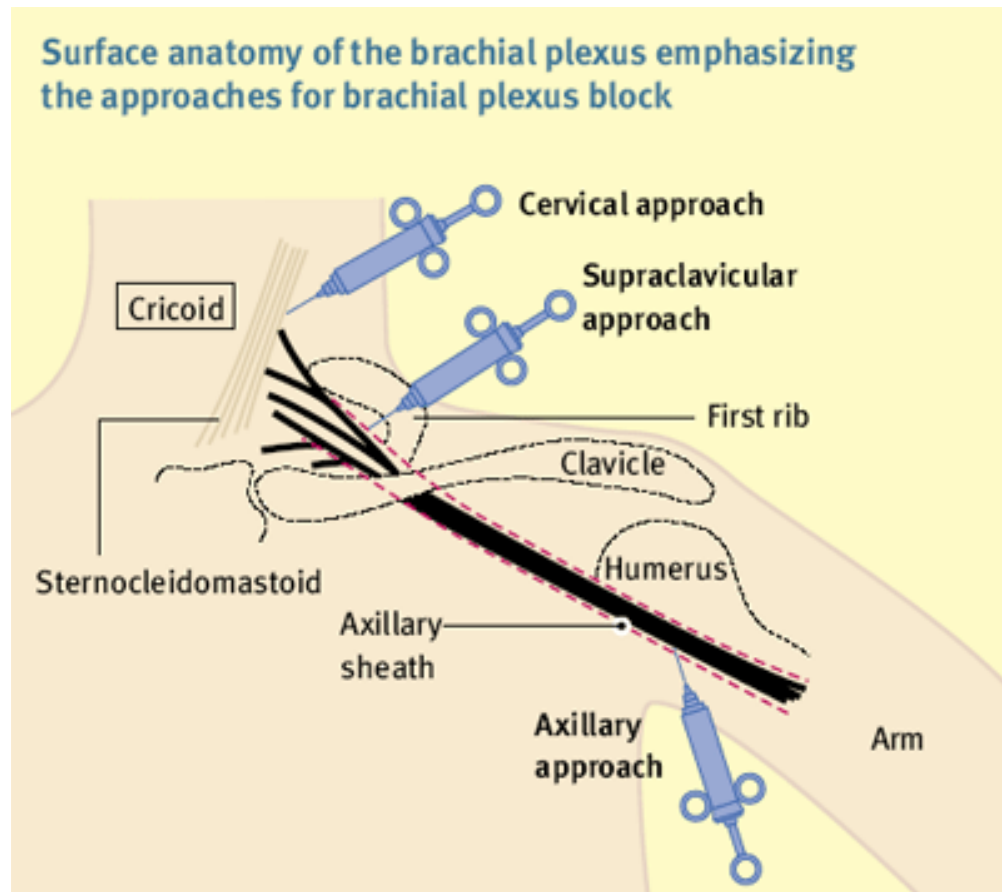
The roots of the brachial plexus, after leaving the transverse process of the corresponding cervical vertebrae, descend in between the scalenus anterior and medius in the posterior triangle of the neck.

Scalenus anterior arises from the anterior tubercles of the transverse processes of C₃ - C₆ Vertebrae. It is inserted into the scalene tubercle on the inner border of the first rib. The muscle lies anterior to the plexus and at its insertion lies anterior to the subclavian artery which separates the plexus from its insertion. Scalenus medius arises from the posterior tubercles of the six lowest cervical vertebrae and is inserted into the upper surface of the first rib behind the groove made by the brachial plexus and the subclavian artery. Thus the plexus lies in front of the muscle.

The first rib lies in an almost horizontal plane being inclined slightly downwards and forwards. It passes below the clavicle at about the junction of its inner and middle thirds. The upper surface of first rib has two transverse grooves - an anterior one for the subclavian vein and a posterior one for the subclavian artery and the lowest trunk of the brachial plexus. On the inner border between the grooves is the scalene tubercle.

Brachial line runs in a straight line from the transverse process of the C₆ vertebra to the axillary artery in the axilla. It runs inferolaterally at an angle of 45 degree from the horizontal plane and slightly forwards at 15 degree.

FIG – 4



TECHNIQUES OF BRACHIAL PLEXUS BLOCK:^(1, 7)

Surgical anaesthesia of the upper extremity and shoulder can be achieved following neural blockade of the brachial plexus at various sites.

The various approaches that can be used for this blockade is as follows:

FIG - 4

- i) Interscalene approach
- ii) Supraclavicular approach
 - a) Classic approach
 - b) Plumb bob technique
 - c) Supraclavicular Perivascular technique
- iii) Axillary approach
- iv) Infraclavicular approach
- v) Posterior approach

INTERSCALENE BRACHIAL PLEXUS BLOCK

TECHNIQUE:

In this technique plexus is blocked at the level of the C₆ vertebra. By standing at the side of the patient and after locating the interscalene groove, an intradermal wheal is raised at the point of needle insertion which is at the level of the cricoid cartilage. A 22 gauge 3.5 cm short bevel needle is inserted “at right angles to the skin in all planes” i.e. dorsal to the horizontal planes. The needle is advanced slowly until paraesthesia sought in the shoulder or a nerve stimulator is used to evoke contractions in the deltoid or biceps brachialis muscle. 20 -40 ml of local anaesthetic injected after repeated aspiration to detect inadvertent entry into vertebral artery or dural cuff.

COMPLICATIONS:

1. Subarachnoid injection
2. Epidural blockade
3. Intravascular Injection
4. Pneumothorax
5. Phrenic nerve block

SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK:

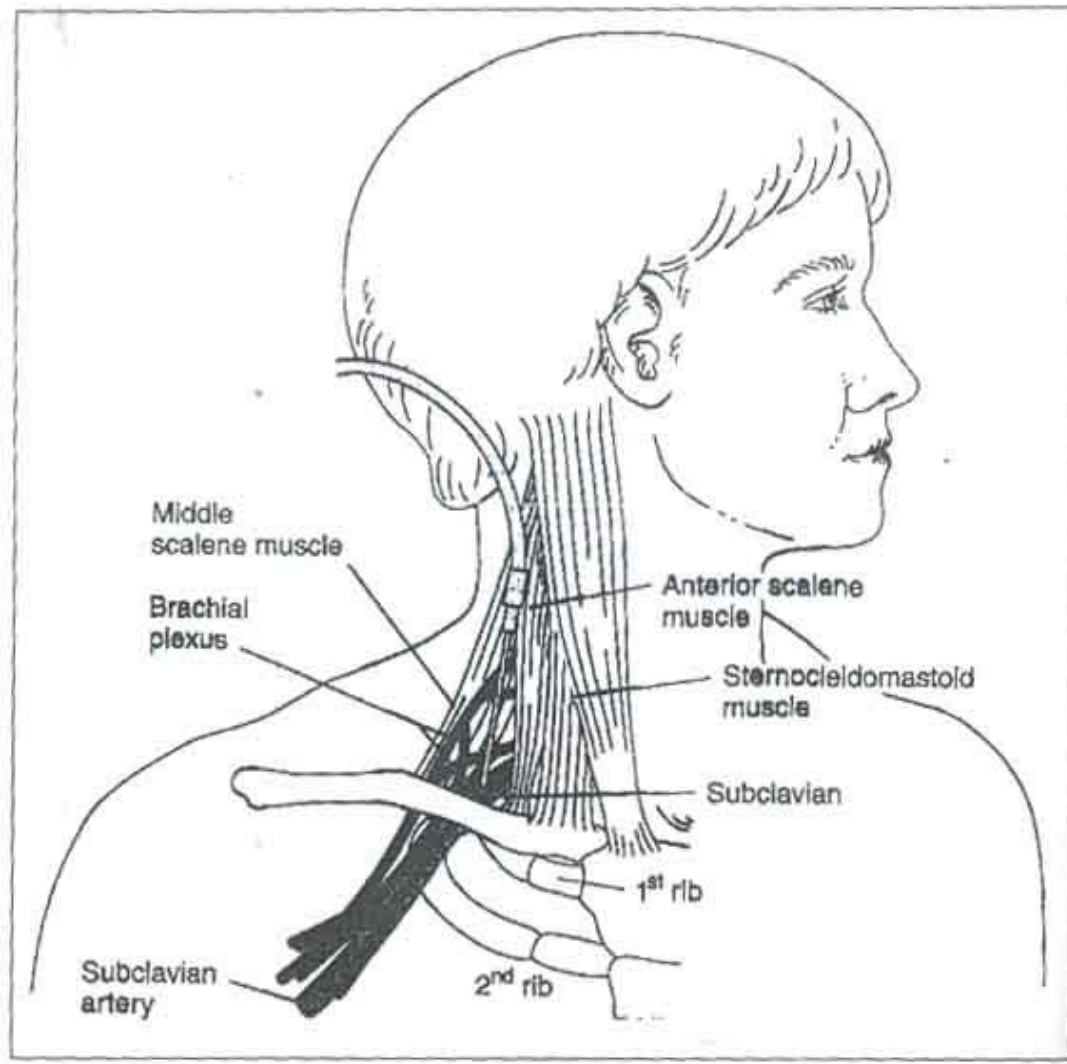
A. CLASSICAL SUPRACLAVICULAR BLOCK OF KULENKAMPFF:

In the classic approach, the needle insertion site is 1 cm superior to the clavicular midpoint. The needle is inserted in a plane parallel to the patient neck and head. The needle will contact the rib at a depth of 3 to 4 cm. The needle is walked over the rib until paraesthesia is elicited. After careful aspiration the local anaesthetic is injected.

B. LUMB BOB SUPRACLAVICULAR BLOCK:

The brachial plexus at the level of the first rib lies posterior and cephalic to the subclavian artery. Once this skin mark has been placed immediately superior to the clavicle at the lateral border of the sternomastoid muscle as it is inserted into the clavicle, the needle is inserted at a 90 degree angle to the table top. The local anaesthesia is injected after eliciting paraesthesia. The name Plumb bob was chosen for this technique because if one suspends a Plumb bob over the entry site, needle inserted through that point will result in contact with the brachial plexus in most patients.

FIG - 5



SUBCLAVIAN PERIVASCULAR TECHNIQUE OF WINNIE AND COLLINS: FIG - 5

The interscalene groove is palpated at its most inferior point, which is just posterior to the subclavian artery pulse. The needle is directed just above and posterior to the subclavian pulse and directed caudally at a flat angle against the skin. The needle is advanced until paraesthesia is elicited and the local anaesthetic is injected after careful aspiration.

COMPLICATIONS:

1. Pneumothorax
2. Horner's syndrome
3. Phrenic nerve block
4. Haemothorax and Haematoma formation.

INFRACLAVICULAR TECHNIQUE:

This is the preferred technique for the surgeries of elbow and lower arm because spread of local anaesthetic is kept below the clavicle. This technique blocks the brachial plexus at the level of cords. The needle is inserted 1 inch beneath the midpoint of the clavicle. It is then directed laterally from this

site at a 45 degree angle away from the chest wall and towards the humeral head or the coracoid process. Once paraesthesia is elicited, the local anaesthetic is injected.

COMPLICATIONS:

1. Pneumothorax
2. Haemothorax
3. Chylothorax with a left side block

AXILLARY BRACHIAL PLEXUS BLOCK:

The pulsations of the axillary artery are best felt high in the axilla between the coracobrachialis and pectoralis major muscle. The needle is inserted just superior to the artery until the resistance of the fascial sheath is felt and a pop indicated the correct needle placement.

COMPLICATIONS:

1. Intra arterial Injection
2. Post Operative neuropathy
3. Hematoma and Infection.

ULTRASOUND GUIDANCE IN REGIONAL ANAESTHESIA

The key requirement for successful regional anaesthetic blocks is to ensure optimal distribution of local anaesthetic around nerve structures. This goal is most effectively achieved under sonographic visualisation. Recent studies have shown that direct visualisation of the distribution of local anaesthetics with high frequency probes can improve the quality and avoid the complication of nerve blocks. Ultrasound guidance enables the anaesthetist to secure an accurate needle position and to monitor the distribution of local anaesthetic in real time.

RATIONALE :

Nerves are not blocked by the needle but by the local anaesthetic. The traditional guidance techniques used in regional anaesthesia have consistently failed to meet this perfectly logical requirement. In addition these methods also are known to produce serious complications. Before the advent of ultrasound it was impossible to verify precisely where the needle tip was located relative to the nerves and how the local anaesthetic was distributed. Ultrasound visualisation of anatomical structures is the only

method of offering safe blocks of superior quality by optimal needle positioning. Also the amount of local anaesthetic required for effective nerve block can be minimised by directly monitoring its distribution.

POTENTIAL ADVANTAGES OF ULTRASOUND GUIDANCE COMPARED WITH CONVENTIONAL TECHNIQUES OF NERVE IDENTIFICATION IN REGIONAL BLOCKS:

- Direct visualisation of nerves and anatomical structures(blood vessels, bone,muscles,tendons)
- Direct and indirect visualisation of spread of local anaesthetic during injection with the possibility of repositioning the needle in cases of maldistribution of local anaesthetic.
- Avoidance of inadvertent intraneuronal and intravascular injection of local anaesthetic solution.
- Avoidance of painful muscle contractions during nerve stimulations in cases of fractures.
- Reduction of dose of local anaesthetic
- Faster sensory onset time

- Longer duration of blocks
- Improved quality of block

PRINCIPLES OF ULTRASOUND:

Ultrasound is high frequency sound generated in specific frequency ranges and sent through tissues. Penetration into tissue is based in large part on the range of the frequency produced. Lower frequencies (2 mhz) penetrate deeper than higher frequencies (10 mhz). As the sound passes through tissues it is either absorbed , reflected or allowed to pass through depending on the echo density of the tissue. All ultrasound waves dissipate in tissues producing heat. The listening part of the probe (a piezo electric crystal) like the generating part of the probe listens for reflections of the sound waves sent out and passes information to the processing unit. Time between sending and receiving equals distance.

The amount of energy reflected which is not absorbed or propagated equals density. Substances with a lot of water like csf and blood are very good conductors of sound and reflect very little are called echoluscent and appear as dark areas. Substances with little water are poor sound conductors like bone reflect all energy and appear very bright. Substances which

conduct sound between these two extremes appear darker to lighter depending on the amount of energy they reflect.

EQUIPMENT

Visualising nerves by sound waves requires the use of high frequencies offering high resolution images. Broad band transducers covering a band width of 5 to 12 MHZ or 8 to 14 MHZ offer excellent resolution of superficial structures in the upper and good penetration depth in the lower frequency range.

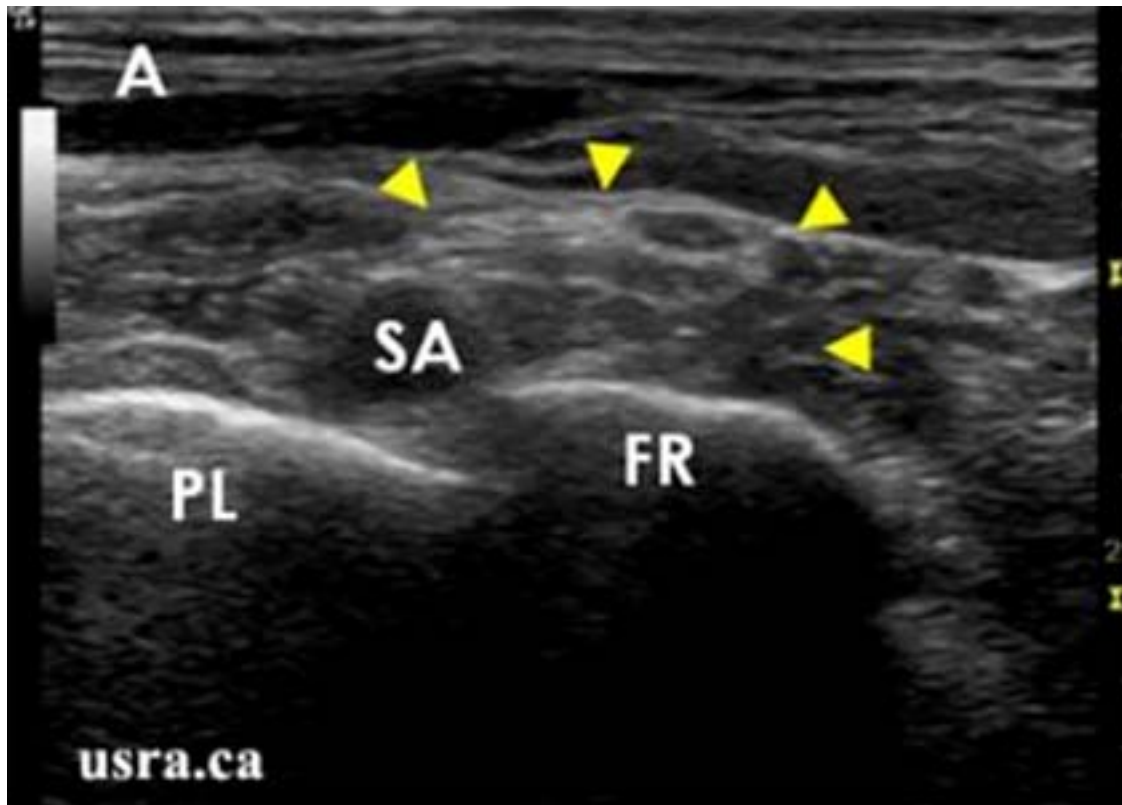
The connective tissue inside the nerves (perineurium and epineurium) reflects ultrasound waves in an anisotropic manner. The angle and intensity of the reflection depends on the angle of the ultrasound wave relative to the long axis of the nerve. The true echogenicity of a nerve is captured only if the sound beam is oriented perpendicularly to the nerve axis. So linear array transducers with parallel sound beam emission is advantageous over sector transducers with diverging sound waves.

The equipment for USG guided nerve blocks should have software to visualise both superficial tissues and musculoskeletal structures. Color and pulsed wave doppler imaging is also required to identify vessels. The equipment should include a high capacity hard disk to store images and short

film sequences. Appropriate portable ultrasound units have also been developed in recent years.

SONOGRAPHIC APPEARANCE OF PERIPHERAL NERVES :

Peripheral nerves may have a hypoechoic(dark structures) or hyperechoic(bright structures) sonographic appearances, depending on the size of the nerve, the sonographic frequency, and the angle of the ultrasound beam. Most blocks are performed on transverse scans, where the nerves appear as multiple round or oval hypoechoic areas encircled by a relatively hyperechoic horizon. These hyperechoic structures are the fascicles of the nerves while the hypoechoic background reflects the connective tissue between neuronal structures.



SA – Subclavian artery

FR – First rib

PL - Pleura

SUMMARY OF ECHO APPEARANCE OF VARIOUS STRUCTURES:

Veins - compressible anechoic(black)

Arteries – pulsatile anechoic(black)

Fat – hypoechoic (black)

Fascia – hyperechoic (white)

Muscle – hypoechoic with hyperechoic striations (white and black)

Tendons – hyperechoic (white)

Cartilage – anechoic (black)

Nerves – hyper or hypoechoic

Local anaesthetic – anechoic (black)

PERIPHERAL NERVE STIMULATION FOR NERVE BLOCKS

INTRODUCTION:

The aim of any regional anaesthesia technique is to locate a nerve or compartment containing nerves and deposit local anaesthetic around the nerve to block nerve conduction. Historically nerve blocks were performed using anatomical landmarks as a guide as to where to insert the needle and elicit paraesthesia. This carries the risk of nerve damage and paraesthesias are only subjective sensation experienced by the patient and may be unpleasant also.

The use of nerve stimulators dates back to 1912 when von perthes described its use. Nerve stimulators have sought to add an objective end point to aid nerve location. They apply a small amount of direct current to the needle which when it is close enough is transmitted to the nerve. The nerve is then stimulated to produce a motor response. An appropriate motor response corresponding to the motor innervations of the desired nerve to be blocked has been shown to improve the success rate of the block.

ELECTROPHYSIOLOGY:

Neurons rest in a state with a negative electric potential inside the cell relative to the outside. This is the resting membrane potential around -70mv. When a neuron is stimulated a transient change in the ion permeability of the membrane occurs with increase in sodium channel conductance. If the stimulus is strong enough it depolarises the membrane to set off an action potential which stimulates the muscle to cause a contraction. The stimulus should be strong enough and applied for a sufficient time to produce an action potential.

CURRENT:

The minimum current required to initiate an action potential in the nerve is called rheobase. Below this level the current cannot initiate an impulse even if it is applied for a prolonged duration. Chronaxie is the length of time the current must be applied to the nerve to initiate an impulse when the current level is twice the rheobase.

The chronaxie varies in different nerves depending on their sensitivities and their refractory periods. Faster conducting nerves like A α motor nerves have a smaller chronaxie due to a shorter refractory period than the slower sensory nerves like A δ or unmyelinated C sensory nerve

fibres. Thus it is possible to stimulate the motor nerve and not the sensory nerve by using a current of smaller chronaxie. This means a motor response can be seen without producing pain.

The threshold current is the lowest current which produces a motor response. A value between 0.2 to 0.5 mA has been suggested to ensure a successful block. Nerve stimulators are designed to be constant current generators. The current between anode and cathode is kept constant irrespective of the impedance of the surrounding tissue. The current output ranges from 0.01 to 5mA. Output is controlled by a dial on the PNS.

IDEAL ELECTRICAL CHARACTERISTICS OF A NERVE STIMULATOR:

- Constant current generator
- Monophasic rectangular output pulse – the current flows in one direction only
- Ability to vary pulse duration (0.1 – 1ms)
- Digital display of actual flowing current
- Safety features-circuit disconnection alert, impedance alert , low battery and malfunction alert.

The usual PNS settings are pulse duration of 0.1ms, frequency of 2Hz and current starting at 1mA.

REVIEW OF LITERATURE

Regional anaesthesia is a well accepted modality to achieve clinical and economic benefits to patients in the perioperative period. These include better intraoperative analgesia, dynamic postoperative analgesia , early physical therapy, reduced incidence of thromboembolic and cardiac events and faster discharge times. This translates to a reduction in morbidity and mortality from surgery. With regional anaesthesia , there is an inherent failure rate even in the best hands. Variations in human anatomy exist and surface anatomical landmarks do not always correlate with structures that lie beneath. Peripheral blocks performed with generation of paraesthesia have a failure rate of 20%. Even electrical nerve stimulation is an objective and indirect guide with limitations that do not guarantee success with peripheral nerve blocks.

The logical requirement of a block to work is the deposition of local anaesthetic in a circumferential distribution around the target nerve so that the drug blocks nerve conduction effectively. For this to prevail it is imperative to have a visual guidance that permits us to visualise the nerve in relation to collateral structures, the needle as it is being advanced towards the nerve , and also the spread of local anaesthetic. Ever since advancement

in ultrasound technology has led to the widespread use of this modality as a guidance tool in regional anaesthesia.

1. Winnie and Ramamoorthy(1977) postulated that the trunks of the brachial plexus are arranged so that the central fibres are longest supplying the extremities of the limb , while the shorter fibres are arranged more peripherally as their area of supply is more proximal.

THUS THE ORDER OF BLOCKADE IS AS FOLLOWS:

Loss of motor power to the shoulder and upper arm, loss of sensation in the upper arm, loss of motor power to the forearm, and loss of sensation to the hand.

2. Lanz E(1983) Studied the extent of blockade using various techniques of brachial plexus blocks. They concluded that the subclavian perivascular approach of winnie resulted in a homogenous blockade of the nerves of the brachial plexus.

3. Franco CD,Vieira ZE(2000) studied subclavian perivascular blok and its success using a nerve stimulator. They concluded that the subclavian technique consistently provides an effective block for surgery on the upper extremity.

4. I.Yasuda et al (1980) used a technique employing a nerve stimulator and an insulated needle for supraclavicular brachial plexus block in 71 patients using 0.5% bupivacaine. The block was successful in 98% patients.
5. Stephan Kapral et al (1994) studied 40 patients undergoing surgery of forearm and hand to investigate the use of ultrasound guidance for supraclavicular brachial plexus block and its effect on the success rate and frequency of complications. They concluded that ultrasound guided approach combines the safety of axillary block with the larger extent of block of the supraclavicular block.
6. Stephan R.Williams et al (2003) assessed the quality, safety, and execution time of supraclavicular block of brachial plexus using ultrasonic guidance and neurostimulation with a technique using neurostimulation alone. The study was conducted on 80 adult patients. They concluded that ultrasound guided neurostimulation confirmed supraclavicular block is more rapidly performed and provides a more complete block.
7. Beach M L et al (2006) evaluated the efficacy of nerve stimulation as an adjunct to ultrasound guided supraclavicular nerve blocks in 94 adult patients. They concluded that for adequately imaged ultrasound guided

supraclavicular blocks, a positive motor response to nerve stimulation does not increase the success rate of the block.

8. Vincent W.S.Chan et al evaluated ultrasound technology for supraclavicular brachial plexus block in 40 outpatients. Needle position was further confirmed by nerve stimulation before injection. The block was successful after one attempt in 95% cases with one failure due to subcutaneous injection and one to partial intravascular injection. There was no pneumothorax. Their data suggest that a high resolution ultrasound probe can reliably identify the brachial plexus and its neighbouring structures in the supraclavicular region. Distinct patterns of local anaesthetic spread observed on ultrasound can further confirm accurate needle location.

9. Abraham et al did a systematic review and meta analysis of randomised controlled studies in ultrasound guided peripheral nerve blocks versus electrical neuro stimulation. They concluded that ultrasound improves efficacy of peripheral nerve blocks compared with peripheral nerve stimulator for nerve localisation.

10. Perlas A et al (2009) conducted a study on 510 patients who received ultrasound guided supraclavicular block for upper extremity surgery. Successful surgical anaesthesia was achieved in 94.6% of patients after a

single attempt. 2.8% required local supplementation and 2.6% received an unplanned general anaesthesia. They concluded that ultrasound guided supraclavicular block is associated with a high success rate and a low rate of complications.

11. Duggan E. et al (2009) evaluated the minimum effective anaesthetic volume required to produce an effective supraclavicular block for surgical anaesthesia using ultrasound guidance. Under the present study conditions, the calculated volume of local anaesthetic does not seem to differ from conventionally recommended volumes using non ultrasound based techniques.

12. De Jose Maria B et al (2008) compared the success rate , complications and time of performance of ultrasound guided supraclavicular versus infraclavicular brachial plexus blocks in children 5 – 15 years old and they concluded that usg guided supraclavicular and infraclavicular blocks are effective in children. There was no pneumothorax and supraclavicular approach of brachial plexus was faster to perform than the infraclavicular one.

13. Nav Prakash S. Sandhu et al 2006 performed infraclavicular blocks with ultrasound guidance in 14 patients with 14 ml of lignocaine. The

reduced volume did not seem to affect the onset but rather shortens the duration of block.

14. C.Morros et al (2009) conducted a study on 129 patients using ultrasound guided axillary block and multiple nerve stimulation, and concluded that ultrasound guidance combined with nerve stimulation improves the anaesthetic quality of axillary brachial plexus block, decreases the likelihood of vascular puncture and slightly increases the amount of time required to perform the procedure.

MATERIALS AND METHODS

This study was carried out in the plastic and orthopaedic surgery theatre, Government General Hospital, Chennai after obtaining institutional approval. The aim of the study was to compare supraclavicular block of brachial plexus using ultrasonic guidance and neuro stimulation with a technique using anatomical landmarks and neurostimulation alone.

STUDY DESIGN:

A prospective, randomised study conducted on 40 ASA I and II patients undergoing upper limb surgeries under supraclavicular brachial plexus block who fulfil inclusion criteria.

The study was started after receiving institutional ethical committee approval and informed written consent from all the patients and they were randomly divided into two groups.

TWO GROUPS:

US - 20ml of 0.5% bupivacaine + 20 ml of 2% lignocaine with 1 in 2 lakh epinephrine

NS -20ml of 0.5% bupivacaine + 20 ml of 2% lignocaine with 1 in 2 lakh epinephrine

INCLUSION CRITERIA:

The following criteria were taken for including the patients in this study.

- Elective surgical patients posted for surgery from middle one third of humerus to hand
- ASA Status I and II
- Age between 18 and 65 years
- Weight >50 kg

EXCLUSION CRITERIA:

- Patient refusal
- Coagulopathies
- Local infections / Sepsis
- H/o significant neurological, psychiatric, neuromuscular, cardiovascular, pulmonary, renal or hepatic disease
- Pregnancy/lactating women

- Peripheral neuropathy
- Allergy to local anaesthetics

MATERIALS:

Sterile tray for regional blocks

1. Drugs for the block

0.5% bupivacaine

2 % lignocaine

Inj.Epinephrine

2. Nerve stimulator stimuplex Dig Rc – B.Braun Germany, needle – 5 cm stimuplex 21G.

3. 7.5 - 10MHZ ultrasonic scanning head and ultrasonic machine 2D with color doppler .

4. Equipments and drugs for resuscitation

5. Equipments and drugs for conversion to general anaesthesia in the case of block failure

METHODS:

PRE OPERATIVE PREPARATION:

Patients were pre-operatively assessed and the procedure was explained to the patient. Written informed consent was obtained. They were assessed with particular attention to any contraindications.

PRE MEDICATION:

Tab.ranitidine 150mg 2 hours before surgery with sips of water.

CONDUCT OF ANAESTHESIA:

On arrival of the patient in the operating room, monitors like pulse oximeter, non invasive blood pressure and ECG were connected and baseline values were recorded. An intravenous access was obtained in the opposite arm.

SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK BY THE SUBCLAVIAN PERIVASCULAR TECHNIQUE⁷

Patients were positioned supine with the head turned away from the side to be blocked and the ipsilateral arm adducted. The neck was prepared with povidone iodine solution and draped with sterile towels.

LANDMARKS:

The essential landmarks to be identified are

1. Cricoid cartilage
2. Interscalene groove
3. Clavicle midpoint
4. Subclavian artery

PROCEDURE:

A line was drawn laterally from the cricoid cartilage to cross the sternomastoid at its midpoint. The interscalene groove was located behind the midpoint of the posterior border of the muscle. To confirm this position the middle and anterior and middle scalene muscles were made prominent by asking the patient to inspire vigorously or sniff. The interscalene groove was then followed distally towards the clavicle. Approximately 1 to 1.5 cm above the midpoint of the clavicle, the pulsation of the subclavian artery was made out in the interscalene groove.

FIG – 6



Under strict aseptic precautions standing by the side of the patient, the interscalene groove was palpated with the index finger, reversing the hands for the opposite side. Patient placed supine with head turned away from the side to be blocked and ipsilateral arm adducted, the interscalene groove and the midpoint of clavicle identified. After local infiltrations of 1 ml of 2% lignocaine intradermally in the interscalene groove 1 to 1.5 cm above the clavicle, a 22G, 5cm short bevelled unipolar insulated needle connected to a nerve locator is directed caudally towards the ipsilateral nipple and posteriorly. End point in a nerve stimulator is a motor response with an output lower than 0.6mA. To avoid intra vascular injection aspiration was done every 3-5 ml of study drug injected.

Supraclavicular blocks in the US group (Fig 6) were performed similarly using a 7.5 - 10MHZ ultrasonic scanning head . After sterile draping and local skin infiltration the probe is placed lateral to the larynx visualising the carotid artery and internal jugular vein. Sterile gel is used between the probe and the skin surface. As the probe is moved sideways the nerve structures in the interscalene groove become visible. The probe is then moved away from the interscalene position to a supraclavicular position. The subclavian artery is visualised and is confirmed by color Doppler. The entire brachial plexus near the artery is then visualised. The nerve bundle is then

confirmed with electrical stimulation eliciting a motor response of wrist or hand motion with a current < 0.6 mA. The needle is entered by an out of plane approach. The local anaesthetic solution is then injected after careful aspiration and is seen encircling the trunks. If the local anaesthetic does not spread in the right direction the needle can be repositioned accordingly.

EVALUATION OF THE BLOCK:

The following observations were made.

- Vital signs monitoring; heart rate, non invasive blood pressure, oxygen saturation and sedation score were measured every minute for the first 5 minutes and every 5 minutes thereafter until the end of surgery. For statistical purposes, they were documented at 0, 1, 2, 5, 10, 15, 30 minutes and every 30 minutes thereafter.
- Block execution time was defined as the interval between the first needle insertion and its removal at the end of the block.
- Immediately following the administration of the drug, patients were evaluated for the onset of sensory and motor blockade every minute.
- Sensory block evaluated by temperature sensation using ether soaked cotton in the skin dermatomes C4-T2.

- Onset of motor blockade was assessed by loss of forearm flexion extension, thumb and second digit pinch and thumb and fifth digit pinch. Only patients with complete motor block are included in the study. Failure of the block to be established even after 20 minutes was taken as block failure.
- Analgesic failure was managed with local anaesthetic supplementation or General anaesthesia as appropriate .
- After confirmation that the block has taken up, surgery was started.
- Patient received supplemental O2 and intravenous fluids throughout the procedure
- Sedation is assessed using Ramsay sedation score (6 points). If the patient is anxious even 1 hour after blocking the plexus, inj. Midazolam was given to achieve a sedation score of 2 to 3.
- Local anaesthetic toxic reactions including subjective and objective manifestations like circumoral numbness, tinnitus, twitching, convulsions, etc., were looked for and appropriate measures were taken.

- a. Complications associated with the technique like intravascular injection, intrathecal or epidural injection and pneumothorax were looked for and appropriate measures were taken to meet any such eventuality.

All the data were subjected to statistical analysis. The parameters of age and sex were analysed using Chi-square test. Block execution time , onset time for motor and sensory blockade, and the success rate were analysed with LEVENE's Test and t-test and the statistical significance estimated. A P value less than or equal to 0.05 was considered statistically significant.

OBSERVATIONS AND RESULTS

The patients included in this study were divided into two groups consisting of 20 patients each.

Group US - received 20ml of 0.5% bupivacaine + 20 ml of 2% lignocaine with 1in 2 lakh epinephrine under USG guided neurostimulation.

Group NS -received 20ml of 0.5% bupivacaine + 20 ml of 2% lignocaine with 1in 2 lakh epinephrine under neurostimulation alone.

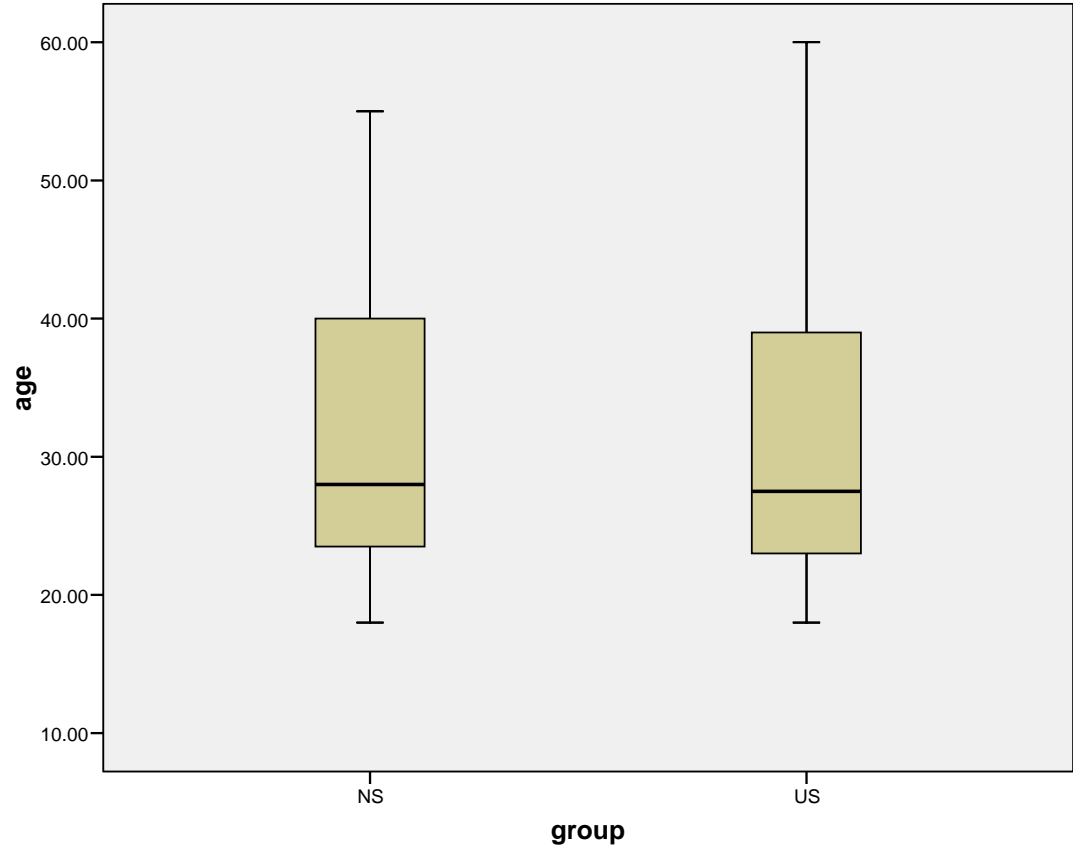
AGE

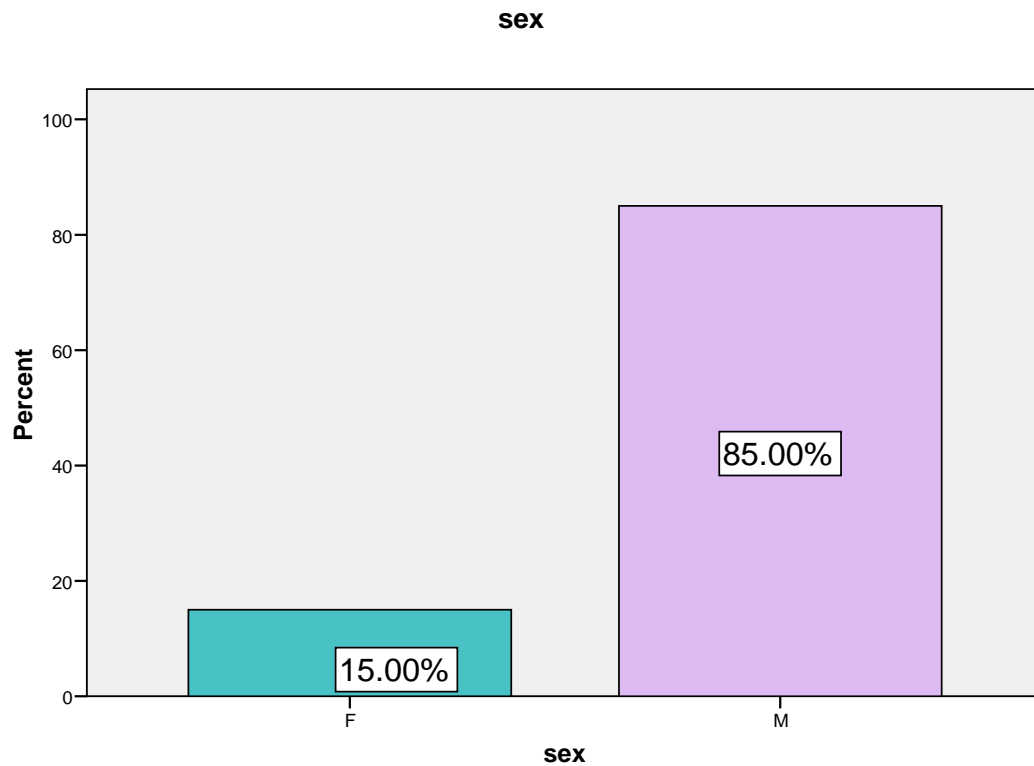
MEAN AGE IN YEARS IN THE TWO GROUPS STUDIED

<i>Group</i>	<i>N</i>	<i>Mean(years)</i>	<i>Median</i>	<i>S.D</i>
US	20	32.50	27.50	12.89
NS	20	32.05	28.00	11.26

STATISTICAL ANALYSIS OF AGE DISTRIBUTION

	<i>Df</i>	<i>F</i>	<i>p Value</i>
Chi-Square test	38	0.275	0.541





SEX

SEX DISTRIBUTION IN THE TWO GROUPS STUDIED

	<i>Value</i>	<i>df</i>	<i>p Value</i>
Chi-square	0.784	1	0.376

There was no statistically significant difference among the two groups as regards sex distribution.

BLOCK EXECUTION TIME (BET)

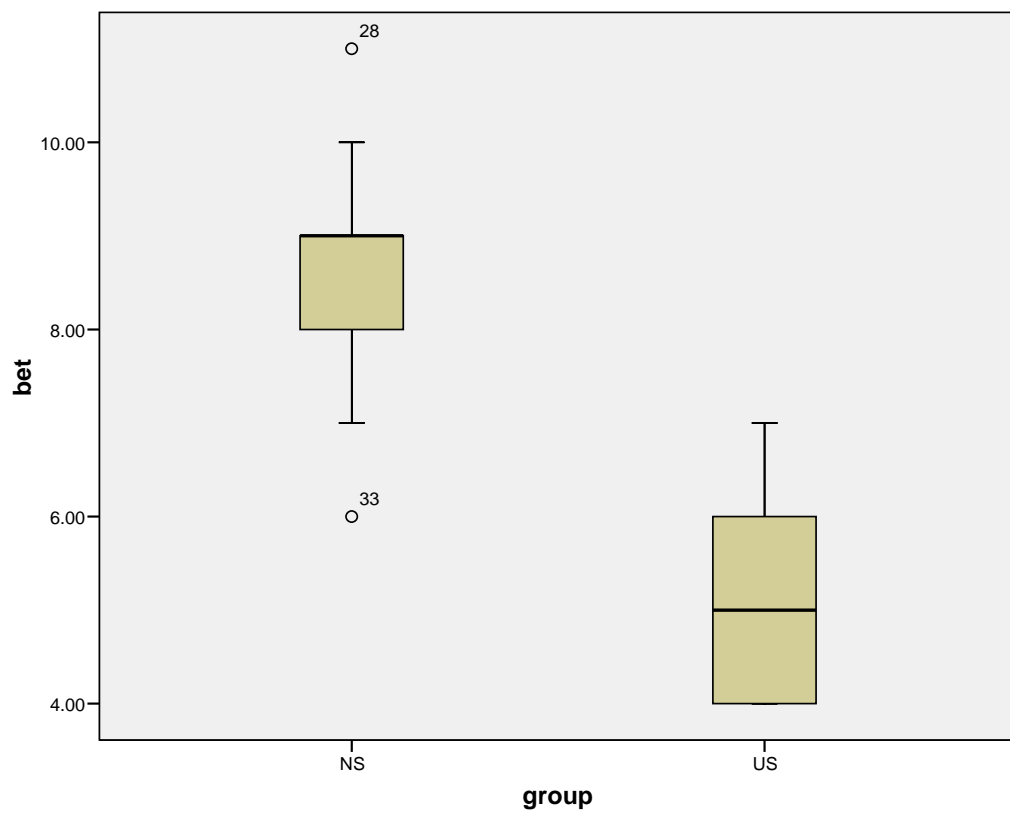
MEAN BLOCK EXECUTION TIME IN MINUTES IN THE TWO GROUPS STUDIED

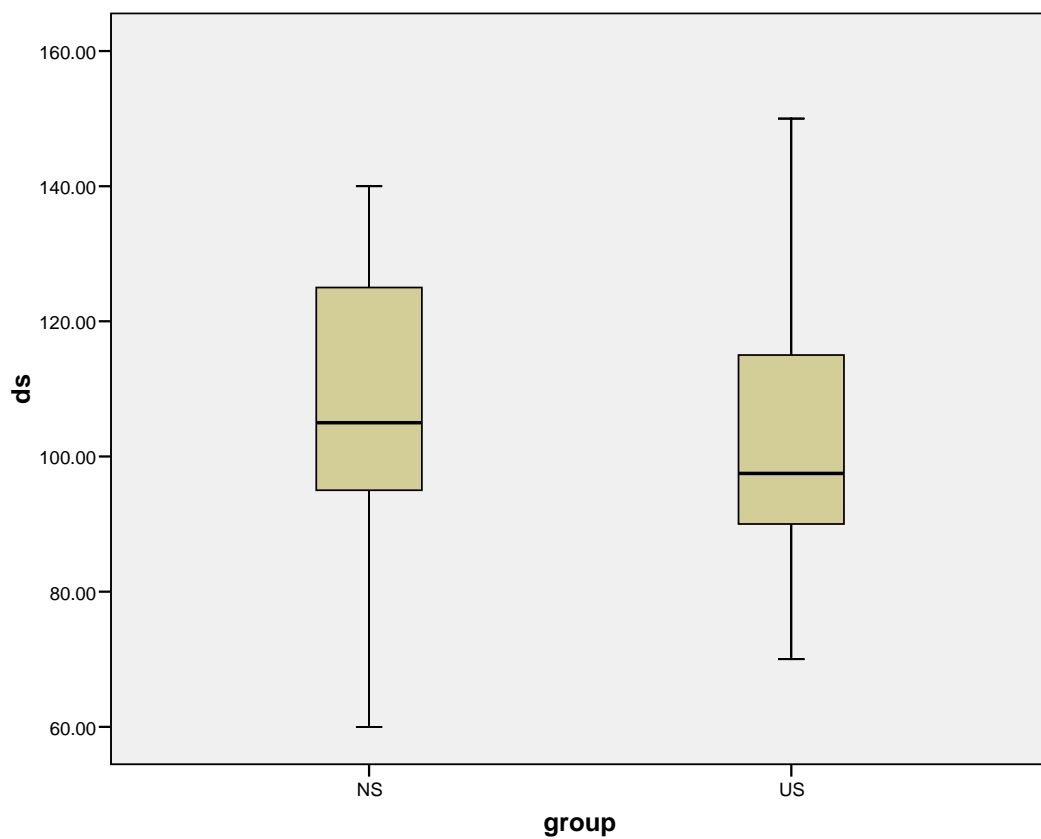
<i>Group</i>	<i>N</i>	<i>Mean(minutes)</i>	<i>Median</i>	<i>S.D</i>
US	20	5.25	5.0	1.164
NS	20	8.6	9.0	1.187

STATISTICAL ANALYSIS OF BLOCK EXECUTION TIME DISTRIBUTION

	<i>Df</i>	<i>F</i>	<i>p Value</i>
Chi-Square test	38	0.092	0.000

Patients in the US group had a shorter block execution time than group NS and the difference was statistically significant.





DURATION OF SURGERY IN MINUTES(ds)
Mean duration of surgery in the two groups

<i>Group</i>	<i>N</i>	<i>Mean (minutes)</i>	<i>SD</i>
US	20	102.75	22.56
NS	20	109.00	21.74

STATISTICAL ANALYSIS OF DURATION OF SURGERY

<i>Levene's test</i>		<i>t test for equality of means</i>		
<i>F</i>	<i>Significant</i>	<i>t</i>	<i>Df</i>	<i>p Value</i>
.000	.985	-.892	38	.378

The duration of surgery in the two groups was not statistically significant.

ONSET OF SENSORY BLOCKADE IN MINUTES (OSB)

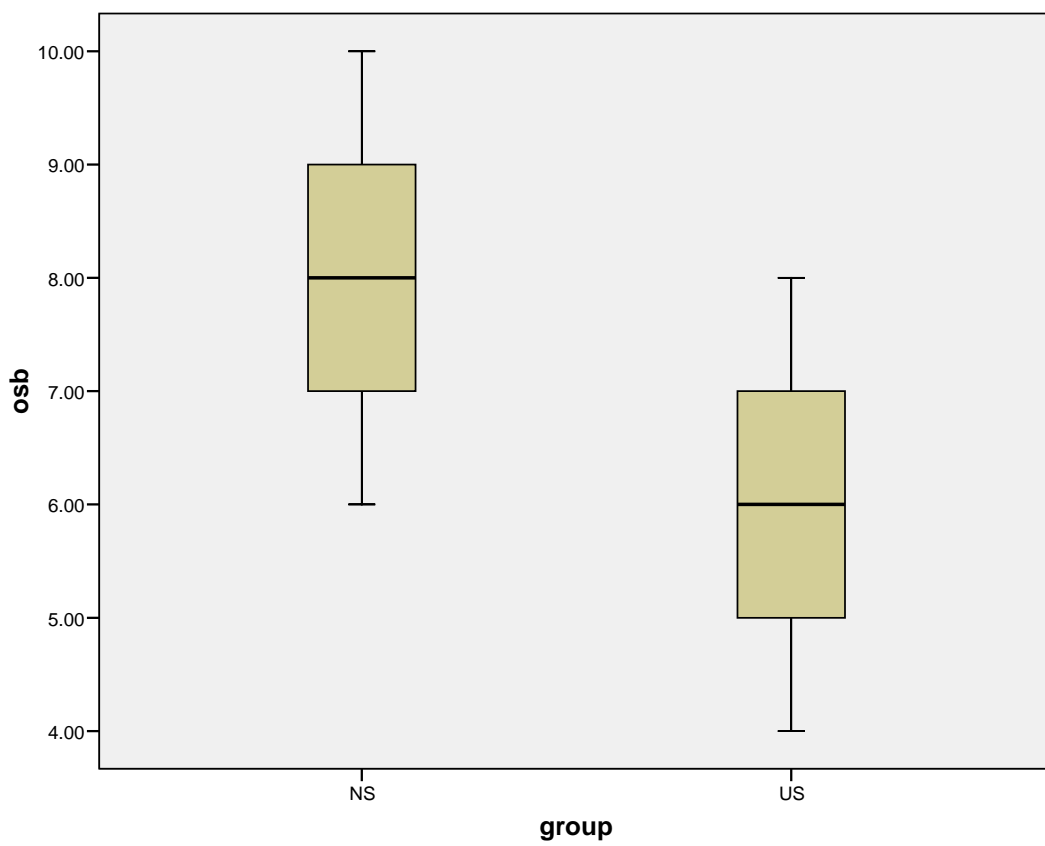
MEAN ONSET OF SENSORY BLOCK IN THE TWO GROUPS

<i>Group</i>	<i>N</i>	<i>Mean(minutes)</i>	<i>SD</i>
US	20	5.90	1.16
NS	20	8.05	1.14

STATISTICAL ANALYSIS OF ONSET OF SENSORY BLOCKADE

<i>Levene's test</i>		<i>t test for equality of means</i>		
<i>F</i>	<i>Significant</i>	<i>t</i>	<i>df</i>	<i>p Value</i>
.061	.806	-5.883	38	0.000

Onset of sensory blockade in the group US was shorter than group NS and the difference was statistically significant.



ONSET OF MOTOR BLOCKADE IN MINUTES (omb)

Mean onset of motor block in the two groups

<i>Group</i>	<i>N</i>	<i>Mean(minutes)</i>	<i>SD</i>
US	20	3.65	0.875
NS	20	5.15	0.875

STATISTICAL ANALYSIS OF ONSET OF MOTOR BLOCKADE

<i>Levene's test</i>		<i>t test for equality of means</i>		
<i>F</i>	<i>Significant</i>	<i>t</i>	<i>df</i>	<i>p Value</i>
0.026	0.872	-5.420	38	0.000

The onset of motor blockade in group US was shorter than the group NS and the difference was statistically significant.

NUMBER OF NEEDLE ATTEMPTS(NNA)

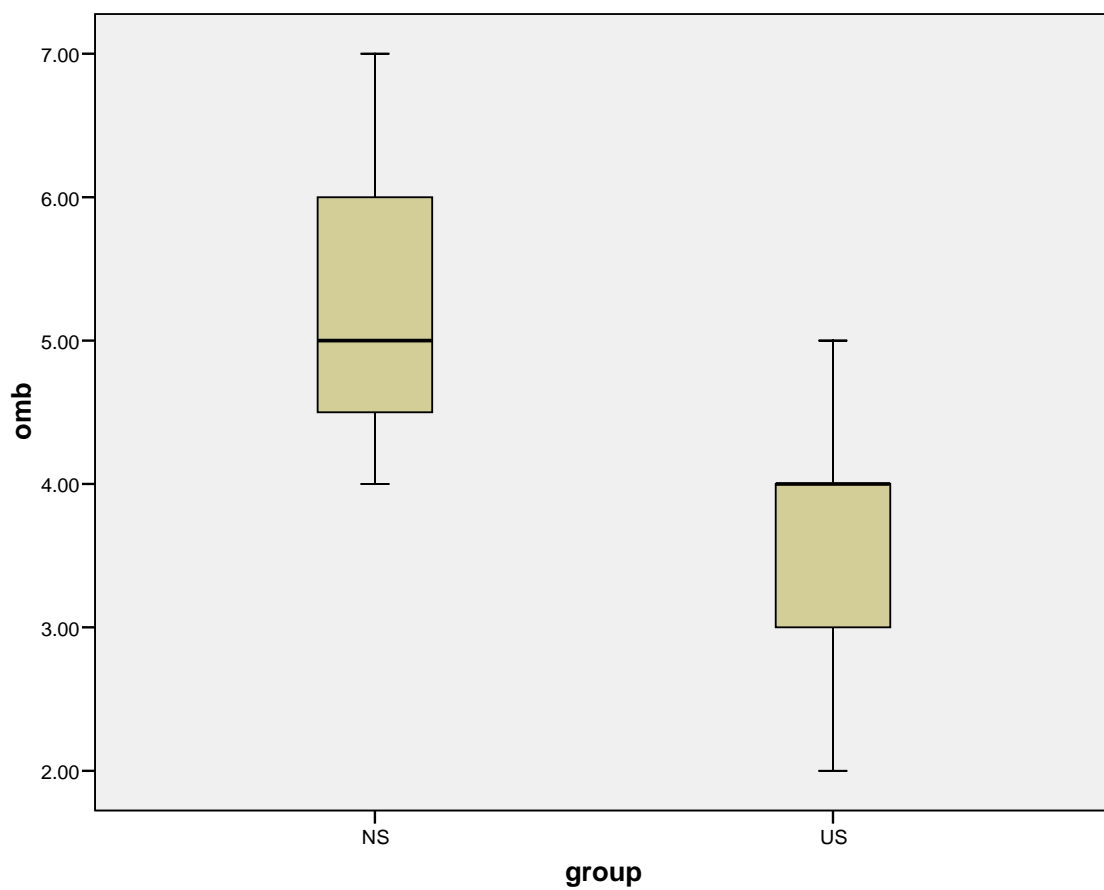
MEAN OF NUMBER OF NEEDLE ATTEMPTS

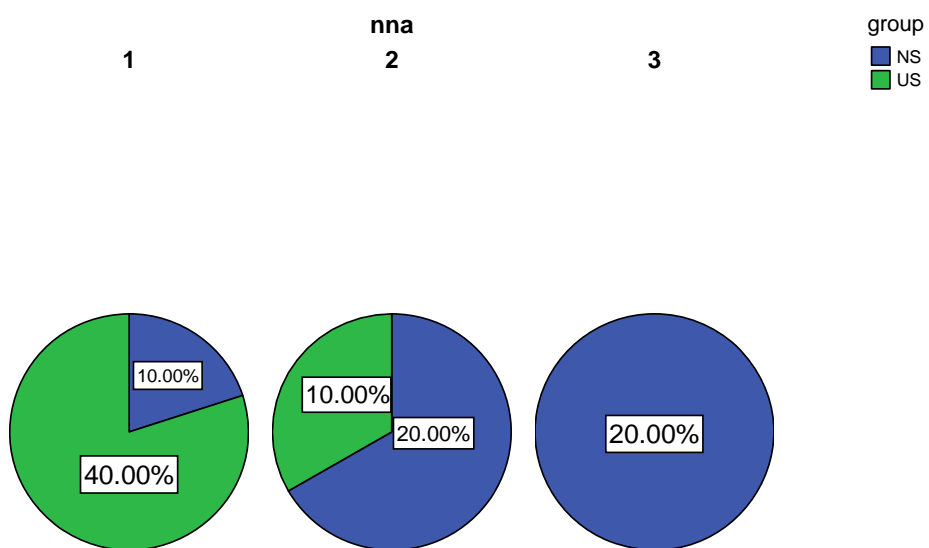
<i>Group</i>	<i>N</i>	<i>Mean</i>	<i>SD</i>
US	20	1.2	0.41
NS	20	2.2	0.76

STATISTICAL ANALYSIS OF NEEDLE ATTEMPTS

<i>Levene's test</i>		<i>t test for equality of means</i>		
<i>F</i>	<i>Significant</i>	<i>t</i>	<i>Df</i>	<i>p Value</i>
9.354	0.004	-5.137	38	0.000

The number of needle attempts was lesser in group US compared to the group NS and the difference was statistically significant.





DISCUSSION

A supraclavicular approach for blockade of brachial plexus was first described by kulenkampf in 1911. The use of supraclavicular blockade has been tempered by the risk of pneumothorax during localisation of the nerve trunks. Interest in supraclavicular block has been rekindled by the use of 2 D ultrasound images to localize the brachial plexus. The sonographic image can be used in real time to guide the injection needle minimising the risk of contact with pleural dome and subclavian artery.

The technology and clinical understanding of anatomical sonography has evolved greatly over the past decade. USG has become a routine technique for regional anaesthesia in many centres. Recent studies have shown that direct visualisation of the distribution of local anaesthetics with high frequency probes can improve the quality and avoid the complications of nerve blocks. The advantages over conventional guidance techniques are significant. Over the past decade the Vienna study group has demonstrated that USG guidance can significantly improve the quality of nerve blocks and avoid complications like intraneuronal and intravascular injection.

In two recent editorials, Grehee and colleagues and Peterson discussed various aspects of using USG to identify nerve structures in regional anaesthesia.

PRESENT STUDY:

The present study was designed to compare supraclavicular blockade using ultrasonic guidance and neurostimulation to a block using a surface anatomy approach and neurostimulation. It was hypothesised that ultrasonic guidance would increase the proportion of blocks allowing pain free surgery without supplementation or need for General anaesthesia, decrease execution times, shorten onset of motor and sensory block and reduce complications.

In the study 40 patients were selected and divided into two groups. The groups were comparable with respect to age, sex, weight and duration of surgery. The differences were statistically insignificant. (p value > 0.05).

VOLUME OF DRUG USED:

In the prospective study by Stephen R. Williams et al, the anaesthetic solution consisted of equal volumes of 0.5% bupivacaine and 2% lignocaine with 1 in 200000 epinephrine administered upto 40 ml for ultrasound guided supraclavicular block. Vincent W.S. Chan et al in their study of USG

neurostimulation for supraclavicular block also used 20 ml of lignocaine 2% with with 1 in 200000 epinephrine and 20 ml of 0.5% bupivacaine. So in the present study similar volumes of local anaesthetic was used.

BLOCK EXECUTION TIME:

In the study by Williams et al , the average time necessary to perform USG guided neurostimulation was significantly shorter (5.0 +/- 2.4 minutes) versus neurostimulation alone.(9.8+/-7.5 minutes). In the present study the block execution study in the US group was 5.25 minutes and in the NS group it was 8.6 minutes and the difference is statistically significant.

NUMBER OF NEEDLE ATTEMPTS:

The number of needle attempts was 1.2 in group US and 2.2 in the group NS. The difference is statistically significant. The study by Chan et al shows that the use of ultrasound minimises the number of needle attempts for nerve localisation.

ONSET OF SENSORY BLOCKADE:

The onset of sensory blockade in group US was quicker (5.90 minutes) than NS(8.05 min) and the difference is statistically significant.

ONSET OF MOTOR BLOCKADE:

The onset of motor blockade in group US was quicker (3.65 minutes) than NS(5.15 min) and the difference is statistically significant.

SUCCESS RATE:

A successful block was defined as anaesthesia sufficient for pain free surgery without supplementation. Blocks in the US group were successful in 19 out of 20 cases(95%) and in the NS group 18 of 20 cases(90%) and the difference is statistically significant . The one failure in the US group was attributed to accidental subcutaneous injection partially.

COMPLICATIONS:

There were no complications seen in both the groups during the study.

SUMMARY

On comparing ultrasound guided neurostimulation and neurostimulation alone with anatomical landmarks for supraclavicular brachial plexus it was found that

- The time taken to perform ultrasound guided nerve stimulation was much shorter compared to neurostimulation alone.
- The number of needle attempts to localise the nerve was minimal with ultrasound use compared to neurostimulation.
- The time of onset of motor and sensory blockade was earlier in the USG group than the neurostimulation group.
- The success rate was higher with the use of ultrasound guided neurostimulation.
- No complications were seen in the two groups.

CONCLUSION

From the study it can be inferred that ultrasound use for supraclavicular brachial plexus block is clinically useful for accurate nerve localisation and to minimise the number of needle attempts. Its use along with neurostimulation allowed statistical and clinically significant decreases in procedure times, quickened onset and provided better success rate than a neurostimulator guided subclavian perivascular approach.

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PATIENT PROFORMA

Name:

Informed written Consent:

Age:

Diagnosis:

Sex:

Surgery:

ASA:

Weight:

MPC:

Comorbid Conditions:

INVESTIGATIONS:

Hb

BT

CT

MONITORS:

HR	NIBP	SaO2

GROUPS:

US	
NS	

TECHNIQUE:

1. Position
2. Needle size
3. No of needle attempts
4. Block execution time
5. Onset of motor block
6. Onset of sensory block
7. Need for supplementation/ conversion
8. Sensory/motor sparing
9. Complications

INTRAOPERATIVE HAEMODYNAMICS:

Time	HR	BP	SaO ₂
0 Min			
1 Min			
2 Min			
3 Min			
4 Min			
5 Min			
10 Min			
15 Min			
20 Min			
25 Min			
30 Min			
35 Min			
40 Min			
45 Min			
50 Min			
55 Min			
60 Min			

Ultrasound guided neurostimulation - group US

S.No	Age	weight in kg	sex	Block execution time in minutes	duration of surgery in minutes	onset of sensory block in minutes	onset of motor block in minutes	No of needle attempts
1	60	50	F	5	140	5	3	1
2	19	55	F	4	70	7	4	1
3	32	70	M	7	100	6	3	2
4	18	55	M	5	100	5	4	1
5	23	63	M	6	80	5	4	1
6	26	55	M	4	90	6	3	2
7	38	60	M	6	80	7	3	1
8	23	55	M	4	95	8	5	1
9	40	80	M	7	120	8	4	1
10	31	60	M	4	130	6	2	1
11	45	50	F	5	150	5	4	2
12	25	60	M	4	90	5	4	1
13	38	65	M	6	90	5	5	1
14	27	60	M	4	80	7	4	1
15	56	70	M	5	110	7	3	1
16	28	60	F	6	90	6	3	2
17	20	55	M	7	100	6	4	1
18	21	60	M	7	110	4	5	1
19	55	60	M	5	140	6	4	1

20	25	75	M	4	90	4	2	1
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Neurostimulation alone - Group NS

S.No	Age	weight in kg	sex	duration of surgery in minutes	Block execution time	onset of sensory block in minutes	onset of motor block in minutes	No of needle attempts
1	45	75	M	130	8	8	6	2
2	40	60	M	100	9	9	5	2
3	50	78	M	140	8	8	5	1
4	25	60	M	140	9	10	6	2
5	28	70	M	80	10	10	7	3
6	28	75	M	120	8	9	6	1
7	38	75	M	90	9	9	5	2
8	20	60	M	60	11	8	4	2
9	18	54	M	100	10	8	5	3
10	55	60	M	140	8	7	5	3
11	20	55	M	120	9	6	6	2
12	29	60	M	90	8	7	5	3
13	20	64	M	100	6	8	4	3
14	28	65	M	90	7	6	4	2
15	25	50	M	120	7	7	6	3
16	50	60	F	130	8	8	5	3
17	28	55	F	100	9	9	4	2
18	22	65	M	110	10	8	4	1
19	32	70	M	100	9	7	5	1
20	40	75	M	120	9	9	6	3

